Advanced Research Center for Beam Science
– Particle Beam Science –

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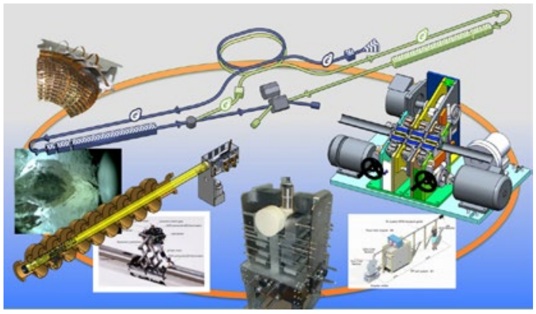
Scope of Research

We are studying particle beam science which includes particle beam generation, acceleration and manipulation for fundamental sciences as well as for practical applications, such as new materials and cancer therapy. We also concentrate on electromagnetics design such as Neutron Optics, including neutron beam focusing to highly enhance their efficiency for advanced measurements. We are the first in the world to demonstrate active neutron acceleration in order to seek the neutron Electric Dipole Moment. In addition, we contribute to advanced fault detection techniques for the International Linear Collider project superconducting accelerating cavities.



KEYWORDS

Beam Physics
Accelerator Physics
Neutron Optics
Phase Rotation
International Linear Collider

Selected Publications

Imajo, S.; Mishima, K.; Kitaguchi, M.; Iwashita, Y.; Yamada, N. L.; Hino, M.; Oda, T.; Ino, T.; Shimizu, H. M.; Yamashita, S.; Katayama, R., Pulsed Ultra-cold Neutron Production Using a Doppler Shifter at J-PARC, *Prog. Theor. Exp. Phys.*, **2016-1,** 013C02-1-22 (2016).

Iwashita, Y.; Tongu, H.; Fuwa, Y.; Ichikawa, M., Compact Permanent Magnet H^+ ECR Ion Source with Pulse Gas Valve, *Rev. Sci. Instrum.*, **87-2,** 02A718-1-02A718-3 (2016).

Fuwa, Y.; Iwashita, Y.; Tongu, H.; Inoue, S.; Hashida, M.; Sakabe, S.; Okamura, M.; Yamazaki, A., RF Synchronized Short Pulse Laser Ion Source, *Rev. Sci. Instrum.*, **87,** 02A911-1-02A911-4 (2016).

Arimoto, Y.; Higashi, N.; Igarashi, Y.; Iwashita, Y.; Ino, T.; Katayama, R.; Kitaguchi, M.; Kitahara, R.; Matsumura, H.; Mishima, K.; Nagakura, N.; Oide, H.; Otono, H.; Sakakibara, R.; Shima, T.; Shimizu, H. M.; Sugino, T.; Sumi, N.; Sumino, H.; Taketani, K.; Tanaka, G.; Tanaka, M.; Tauchi, K.; Toyoda, A.; Tomita, T.; Yamada, T.; Yamashita, S.; Yokoyama, H.; Yoshioka, T., Development of Time Projection Chamber for Precise Neutron Lifetime Measurement Using Pulsed Cold Neutron Beams, *Nucl. Instr. Meth. Phys. Res. A*, **799,** 187-196 (2015).

Yamada, M.; Iwashita, Y.; Ichikawa, M.; Fuwa, Y.; Tongu, H.; Shimizu, H. M.; Mishima, K.; Yamada, N. L.; Hirota, K.; Otake, Y.; Seki, Y.; Yamagata, Y.; Hino, M.; Kitaguchi, M.; Kennedy, S. J.; Lee, W. T.; Andersen, K. H.; Guerard, B.; Manzin, G.; Geltenbort, P., Pulsed Neutron-beam Focusing by Modulating a Permanent-magnet Sextupole Lens, *Prog, Theor. Exp. Phys.*, **2015,** 043G01 (2015).

Kubo, T.; Iwashita, Y.; Saeki, T., Radio-frequency Electromagnetic Field and Vortex Penetration in Multilayered Superconductors, *Appl. Phys. Lett.*, **104,** 032603 (2014).

Measurement of Thermal Cross Section of $^{14}N(n,p)^{14}C$ Using Cold Neutron Beam at J-PARC

The cross section of the $^{14}N(n,p)^{14}C$ reaction is one of the key parameters in the slow-neutron capture process of stellar nucleosynthesis occurring in the helium burning shells whose typical temperature is ~25 keV. In late 1980s, the $^{14}N(n,p)^{14}C$ reaction cross section at around 30 keV have been measured by two groups, and their results deviated from each other by a factor of more than two. One of them has been supported by later measurements, but the extrapolated cross section of their results assuming the 1/v law differs from the recent evaluated cross section with the deviation of more than 1.6 σ.

To improve the reliability of the evaluated cross section data, we measured the thermal cross section of the $^{14}N(n,p)^{14}C$ reaction using a pulsed cold neutron beam at J-PARC (Japan Proton Accelerator Research Complex). Our experiment has a feature that the $^{14}N(n,p)^{14}C$ and $^{3}He(n,p)^{3}H$ reactions are measured simultaneously by Time Projection Chamber (TPC), where the cross section of the latter reaction has been measured within the error of 0.13% as 5333(7) barn. The TPC, which was originally developed for a neutron lifetime measurement by the NOP (Neutron Optics and Physics) collaborators at J-PARC (Figure 1), consisted of a drift cage with a multi-wire proportional chamber (MWPC) inside the seal-off vacuum vessel (Figure 2). An operational gas was the mixture of 80 kPa ^{4}He, 20 kPa N_2, and a few Pa ^{3}He, where the partial pressures were measured by the gas injection system.

Pulsed cold neutron beams in the energy range of 1~20 meV are produced by the nuclear spallation reaction of Hg target using a 3 GeV pulsed proton beam at MLF (the Materials and Life Science Facility). Since the length of a neutron bunch is 40 cm which is shorter than the length of the TPC sensitive volume, background events caused by neutron capture reactions in materials of inner walls or frames of the TPC could be reduced by selecting only the events whose particle tracks were fully contained in the sensitive volume. Since the Q-values of the $^{14}N(n,p)^{14}C$ and $^{3}He(n,p)^{3}H$ reactions are 626 keV and 764 keV, respectively, they were able to be separately detected by the deposit energy difference of the reactions (Figure 3). Thus we could deduce the thermal cross section of $^{14}N(n,p)^{14}C$ relative to the thermal cross section of $^{3}He(n,p)^{3}H$ by using the known ratios of the target densities of ^{14}N and ^{3}He and the detection efficiencies for (n,p) reactions on those nuclei.

To check the quality of the separation between the $^{14}N(n,p)^{14}C$ and $^{3}He(n,p)^{3}H$ reactions in the energy spectrum, we made measurements using the operational gases with three different partial pressures of ^{3}He, and obtained a preliminary result on the thermal cross section of the $^{14}N(n,p)^{14}C$ reaction as 1.864(3) barn with the world best accuracy of 0.3%.

The method of our experiment is in principle applicable to the measurements of other (n,p) and (n,α) reaction cross sections, for example, $^{10}B(n,p)^{10}Be$, which is also one of the important reactions in astrophysics. We are considering a measurement of the thermal cross section of the $^{10}B(n,p)^{10}Be$ reaction in a near future.

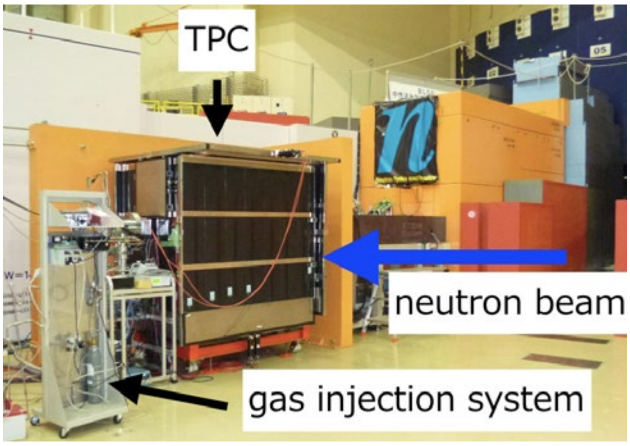


Figure 1. Experimental set up at J-PARC/MLF Beam Line 05.

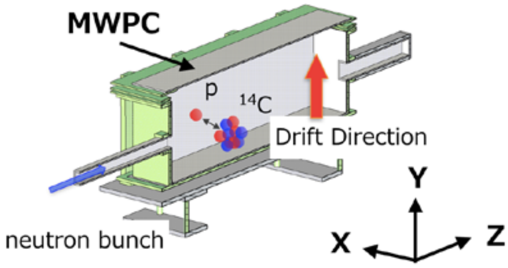


Figure 2. Schematic drawing of the Time Projection Chamber (TPC). Electrons ionized by a charged particle in the operational gas drift to the multi-wire proportional counter (MWPC). Deposit energy in the TPC is determined by measuring an amount of the electrons detected by MWPC.

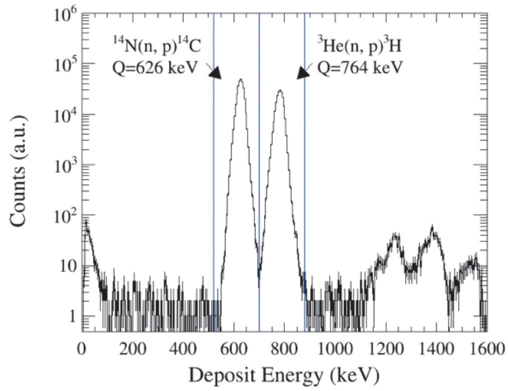


Figure 3. Deposit energy distribution in the measurement with the ^{3}He partial pressure of 9 Pa. The peaks corresponding to the $^{14}N(n,p)^{14}C$ and $^{3}He(n,p)^{3}H$ reactions are found in the energy regions of 520~700 keV and 700~880 keV, respectively, and are well separated with the threshold level of 700 keV (blue line).